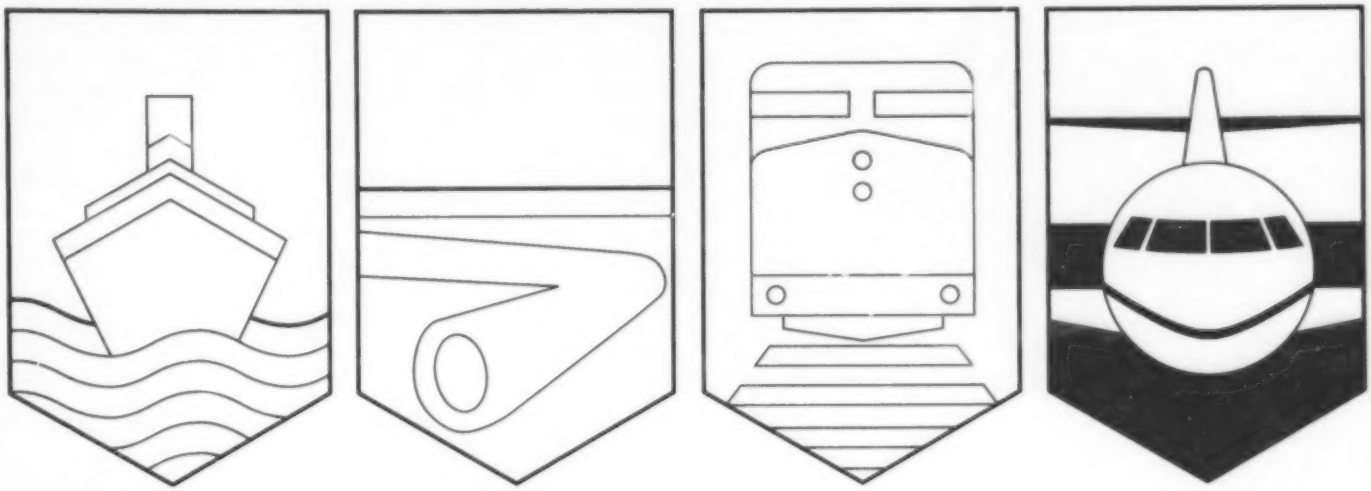
Canadian Transportation
Accident Investigation
and Safety Board

Bureau canadien d'enquête
sur les accidents de transport
et de la sécurité des transports



AVIATION OCCURRENCE REPORT

AIR TUTEURS LTÉE
CESSNA 402B C-GLUC
CHARLO, NEW BRUNSWICK
22 February 1988

REPORT NUMBER 88A0047

Canada

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The Canadian Transportation Accident Investigation and Safety Board investigated this occurrence for the purpose of advancing transportation safety. It is not the function of the Board to assign fault or determine civil or criminal liability.

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SYNOPSIS

The Cessna 402B, C-GLUC, was on an instrument flight rules charter flight from St. Hubert, Quebec to Bonaventure, Quebec via Presque Isle, Maine and Charlo, New Brunswick. The crew carried out an instrument landing system approach to runway 13 at Charlo, advised Charlo Flight Service Station that they were visual, cancelled their instrument flight rules flight plan, and advised Charlo FSS that they were proceeding to Bonaventure at 1,000 feet above sea level. The aircraft overflew Charlo Airport at 1738 Atlantic standard time and crashed about two minutes later on the snow-covered frozen surface of Baie des Chaleurs. All six occupants perished in the accident, and the aircraft was destroyed.

28 June 1990

Ce rapport est également disponible en français.

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1.0 FACTUAL INFORMATION

1.1 History of the Flight

C-GLUC, a Cessna 402B owned and operated by Air Tuteurs Ltée., was on an instrument flight rules (IFR)* charter flight from St. Hubert, Quebec to Bonaventure, Quebec via Presque Isle, Maine and Charlo, New Brunswick.

Over Bonaventure, at 4,000 feet above sea level (asl)**, the aircraft was above the cloud base. The crew then requested and received clearance to Gaspé, Quebec for an instrument approach. As they were receiving their clearance, the pilot changed his mind and requested an approach at Charlo, with the intention of acquiring visual meteorological conditions (VMC) and proceeding under visual flight rules (VFR) back to Bonaventure, 35 nautical miles away.

The crew carried out a normal instrument landing system (ILS) approach to runway 13 at Charlo as witnessed by several people on the ground; they then advised Charlo Flight Service Station (FSS) that they were visual, cancelled their IFR flight plan, and advised that they were proceeding to Bonaventure at 1,000 feet VFR. The aircraft overflew Charlo Airport at 1738 Atlantic standard time (AST)*** and crashed 2 minutes and 11 seconds later on the snow-covered, frozen surface of Baie des Chaleurs, four nautical miles east of Charlo Airport. All six occupants perished in the accident.

The accident occurred at sea level at lat 48°00'00"N, long 66°13'14"W, at 1740 AST during the hours of daylight.

1.2 Injuries to Persons

	Crew	Passengers	Others	Total
Fatal	2	4	-	6
Serious	-	-	-	-
Minor/None	-	-	-	-
Total	2	4	-	6

* See Glossary for all abbreviations and acronyms.
** Units are consistent with official manuals, documents, reports, and instructions used by or issued to the crew.
*** All times are AST (Coordinated Universal Time (UTC) minus four hours) unless otherwise stated.

1.3 Damage to Aircraft

The aircraft was destroyed.

1.4 Other Damage

There was no other damage.

1.5 Personnel Information

	Pilot-In-Command	Co-Pilot
Age	57	32
Pilot Licence	Airline Transport	Commercial
Medical Expiry Date	01/03/88	01/06/88
Total Flying Time	22,000 hr	1,120 hr
Total on Type	41 hr	75 hr
Total Last 90 Days	41 hr	129 hr
Total on Type Last 90 Days	34 hr	3 hr
Hours on Duty Prior to Occurrence	10.5 hr	9.5 hr
Hours off Duty Prior to Work	16.0 hr	17.0 hr

1.5.1 Crew Experience

The captain was properly licensed and qualified for the flight and was occupying the left seat. He had a high total flying time and was an experienced instrument pilot. A review of his personal logbook and flying history, however, revealed that most of his flying experience had been as an instructor and in urban areas.

The co-pilot was properly licensed and qualified for the intended flight, but he had limited experience flying IFR. He obtained his Instrument Rating 10 months before the occurrence and had not flown IFR in the last 90 days. His logbook indicated that he had flown seven hours under actual instrument meteorological conditions (IMC) and 21 hours under simulated IMC. He was occupying the right seat and was identified as the pilot operating the radios. He did not have a Pilot Proficiency Check (PPC) on the aircraft, nor was any required because the company Operating Certificate authorized the captain to conduct the flight without a co-pilot.

The captain normally flew alone in IFR operations, and he had flown once with this particular co-pilot in the last 90 days.

1.6 Aircraft Information

Manufacturer	Cessna Aircraft Company
Type	Model 402B
Year of Manufacture	1978
Serial Number	402B1318
Certificate of Airworthiness	Valid
Total Airframe Time	2,486 hr
Engine Type (2)	Continental TSIO-520-E
Propeller Type (2)	McCauley 3AF32C87-N
Maximum Allowable Take-off Weight	6,300 lb
Recommended Fuel Type	100/130

The aircraft was equipped for IFR flight in known icing conditions and had dual flight instruments. The aircraft was maintained in accordance with the maintenance standards for the aircraft, and all applicable maintenance checks had been conducted. The Certificate of Airworthiness was valid. There were no deferred maintenance items at the time of flight.

The fuel system in the aircraft consisted of two main tanks, each with a capacity of 41.6 Imperial gallons (50 U.S. gallons), and two auxiliary tanks, each with a capacity of 26.2 Imperial gallons (31.5 U.S. gallons). The total fuel capacity was 135.7 Imperial gallons (163 U.S. gallons). Refuelling records showed that the fuel tanks were all full on departure from St. Hubert.

It was estimated that, at the time of take-off from St. Hubert, the aircraft weighed approximately 6,700 pounds, which was about 400 pounds over the maximum allowable gross weight of 6,300 pounds. One unexpected passenger was boarded just prior to departure. The centre of gravity was estimated to have been within the prescribed limits.

The captain's altimeter was found to be set at 29.77 inches of mercury (in. Hg), and the co-pilot's was at 29.79 in. Hg; the altimeter setting given to the crew by Charlo FSS was 29.75 in. Hg.

1.7 Meteorological Information

The area was under the influence of an approaching warm front with cloud layered between 2,000 and 20,000 feet. Some light to moderate ice was possible while in cloud, with the freezing level at the surface.

At the time of the occurrence, the weather, from observations taken at Charlo, was as follows:

1700 AST - Sky partially obscured, measured ceiling 1,200 feet overcast, visibility one mile in light snow; temperature -12 degrees Celsius, dew point -13 degrees Celsius; and wind 090 degrees true at 13 knots.

1706 AST - Sky partially obscured, measured ceiling 2,800 feet overcast; visibility two miles in light snow.

1800 AST - Sky partially obscured, measured ceiling 2,000 feet overcast, visibility two miles in light snow; temperature -12 degrees Celsius; dew point -13 degrees Celsius; and wind 100 degrees true at six knots.

There is no weather reporting station for Bonaventure, Quebec.

1.8 Aids to Navigation

1.8.1 Charlo, New Brunswick

Charlo Airport has an ILS approach to runway 13. The captain used this approach to penetrate the cloud and convert his flight from IMC to VMC. The ILS system was functioning normally.

1.8.2 Bonaventure, Quebec

Bonaventure Airport is served by a private non-directional beacon (NDB) owned by the Government of Quebec. There is a beacon approach procedure approved by Transport Canada for use by the Quebec Government. Air Tuteurs Ltée. had approval to use this approach, but it was not possible to determine if the pilots had the appropriate approach plate on board.

1.8.3 Gaspé, Quebec

Gaspé Airport is served by both ILS and NDB approaches.

1.9 Communications

1.9.1 Charlo, New Brunswick

Charlo Airport has an FSS which operates on frequencies 122.2 and 126.7 megahertz (MHz). C-GLUC established contact with Charlo FSS on 122.2 MHz. The two-way communication functioned normally.

1.9.2 Bonaventure, Quebec

Bonaventure Airport has a remote communications outlet (RCO) operated on frequency 122.0 MHz by Gaspé FSS. At 1740 AST, eight seconds before the impact, C-GLUC attempted to make initial contact with Gaspé through Bonaventure RCO. Gaspé replied, but two-way contact was never established.

1.10 Aerodrome Information

Not pertinent.

1.11 Flight Recorders

The aircraft was not equipped with a flight data recorder (FDR) or a cockpit voice recorder (CVR), nor was either required by regulation.

1.12 Wreckage and Impact Information

The aircraft hit the surface of Baie des Chaleurs, four nautical miles east of Charlo Airport, while in a wings-level attitude and on a descent path of about two degrees. The aircraft bounced, then hit right-wing-low and began to cartwheel and break up. The distance from the initial point of impact to the end of the wreckage trail was 750 feet.

Both propellers separated from the engines at the shaft, and both engines were torn from their mounts. Both wings separated from the fuselage in one piece, and then the outboard section of the right wing broke away from the main section. The fuselage broke just behind the cockpit, and the top of the cockpit area was torn away. The rear section of the fuselage folded forward and came to rest parallel to the front section. All the occupants were thrown from the aircraft during the breakup sequence. The passengers in the left front and rear seats had their seat-belts fastened. It could not be determined whether other belts were fastened.

1.13 Medical Information

There is no evidence that incapacitation, physiological, or psychological factors affected the crew's performance. The toxicological report from the Civil Aviation Medical Unit showed no evidence of alcohol or common drugs identified, and the crew's deaths were attributed to extensive multiple skull fractures and cerebral hemorrhage.

There was evidence in the autopsy of one of the passengers of a recent heart attack, either before or possibly at impact.

1.14 Fire

There was no evidence of fire either before or after the occurrence.

1.15 Survival Aspects

The accident was not survivable due to the magnitude of the deceleration forces.

1.16 Tests and Research

1.16.1 Aircraft Tests

The engines were disassembled and examined. No evidence of pre-impact failure or malfunction was evident.

Both propellers were disassembled and examined. No evidence of pre-impact failure or malfunction was evident. Witness marks on the inner hubs indicated that, at impact, the propellers were operating at a pitch angle consistent with cruise power.

The aircraft structure was examined in detail, and there was no evidence of pre-impact failure. At the time of impact, the aircraft was in a cruise configuration with the flaps and wheels retracted, and the controls were in the neutral position. There was no evidence of fire, explosion, or sabotage.

Both vacuum systems were examined, and they were determined to be serviceable at the time of impact.

The left altimeter was set at 29.79, reading approximately 50 feet and the right altimeter was set at 29.77, reading approximately 70 feet. Shortly before the occurrence, C-GLUC received the Charlo altimeter setting which was 29.75 in. Hg. The altimeters had been overhauled approximately one month before the accident, and there was no evidence of pre-impact unserviceability.

An examination of the electrical system indicated that power existed at the time of the impact. The right alternator (Prestolite, P/N 9407) was examined, and it

was found that the slip rings were in an advanced state of deterioration, a condition which indicated the alternator was at or near failure at the time of the accident.

The condition of the R ALT OUT warning light bulb showed that the light was not illuminated at impact.

Examination of the fuel and oil showed that they met operating specifications and were free of contaminants.

1.16.2 Other Tests

Herron Island is an island six nautical miles east of Charlo Airport and lies along the flight path between Charlo and Bonaventure. This island is level and rises only a few feet above sea level. At the time of the accident, it was covered with snow and it blended with the snow-covered ice of the bay, except for the shoreline. The shoreline, viewed from an aircraft on that flight path and in the existing weather conditions, would have appeared as a very thin black line.

Two CTAISB investigators, using a Beechcraft King Air 90, retraced the flight of GLUC to determine the flight profile of the aircraft if the pilot had mistaken the shoreline of Herron Island for the horizon. Four flights were flown, and each time the King Air aircraft flew a profile to the exact site of the accident.

1.17 Additional Information

1.17.1 Passenger Seats

In this aircraft, the front pair of passenger seats faced rearward. The other four passenger seats faced forward. This configuration is known as "club-seating." To ensure structural strength in this configuration, seats must have large seat rail slipper clamps under the legs which face the rear of the aircraft. This, in fact, means the rearward facing seats have their large clamps on the front legs.

Two seats in this aircraft were installed incorrectly. The rearward facing right seat from the first row was interchanged with the forward facing left seat from the second row. These two seats had the large slipper clamps located toward the front of the aircraft.

1.17.2 Emergency Locator Transmitter Design

The emergency locator transmitter (ELT) installation consisted of an internal, fuselage-mounted transmitter and an external, fuselage-mounted antenna. The two units were joined by a "lead-in" wire. During the accident, this wire broke; as a result, the ELT signal was very weak and was not received by Charlo FSS.

1.17.3 Search and Rescue Alerting

The ELT signal was received by Search and Rescue satellite (SARSAT) at 1927 AST, about 1 hour 47 minutes after the accident.

The aircraft was flight planned to Bonaventure, Quebec. According to Transport Canada procedures, Gaspé FSS had the final responsibility for Search and Rescue alerting. When GLUC first arrived over Bonaventure, the crew requested, from Montreal Area Control Centre (ACC) via Moncton ACC, an approach at Gaspé. Within moments, the crew changed their request to an approach at Charlo. Moncton advised Gaspé, via relay through Montreal ACC, that GLUC was "going to Charlo", therefore Gaspé FSS filed away all flight planning documents on GLUC. Gaspé FSS assumed that the aircraft was landing at Charlo and that Charlo FSS had alerting responsibility.

Charlo FSS had been in radio contact with GLUC during its approach at Charlo and knew that GLUC was going to Bonaventure. However, Charlo FSS did not realize that Gaspé FSS had been told GLUC was "going to Charlo" and that Gaspé was no longer carrying Search and Rescue alerting responsibility. This confusion, combined with the fact that the ELT signal was too weak for Charlo FSS to receive, resulted in Search and Rescue not being alerted until they received the SARSAT signal.

1.17.4 Whiteout

It is generally accepted that there are two kinds of whiteout: one condition where, due to blowing snow, visual cues are obscured and we immediately perceive that visibility is drastically reduced; and another, more insidious condition called atmospheric whiteout. In this condition, visibility may not be markedly diminished, but, due to loss of the horizon and gradient cues, depth perception and distance judgement are lost, possibly without the observer being aware. Continued flight into whiteout conditions is possible and safe only if the pilot recognizes the phenomenon and changes from visual to instrument flight.

The Department of National Defense publication, "Investigation of Human Factors in Aircraft Accidents", published in 1975, discusses this subject as follows:

"The well-trained pilot normally doesn't have too much problem with "white-out" in that he adjusts to the condition as soon as its existence is recognized. With no visual reference to the ground he switches to instruments. The trouble is, however, that unless there is a complete lack of visual contact there is a tendency to use whatever exists as the reference. A line of trees, bushes, a fence, road or even solitary building gives a false sense of security in establishing altitude, attitude, and height."

1.17.5 Terrain Features and Visual Cues

As GLUC overflew Charlo Airport, the crew of GLUC was in transition from IFR to VFR flight in reported visibility reduced to two miles in light snow. Once the aircraft had crossed the airport, there were few visual cues to provide contrast between the overcast sky and the ground. There was only snow-covered ground, with a few houses, a highway, and an obscure shoreline. Two nautical miles east of the airport, the aircraft flew over a featureless, frozen, snow-covered expanse of water. There was an island four nautical miles ahead; however, this was also featureless except for some small alder trees and a narrow black line that defined the island's near shoreline.

2.0 ANALYSIS

2.1 Introduction

The investigation of this accident included an on-site examination, shop disassembly, laboratory analysis, pathological investigation, human factors research, and an analysis of the weather in combination with the terrain features encountered by the pilot.

2.2 Consideration of Evidence

There was no evidence of any aircraft malfunction; the aircraft was in controlled flight, in a shallow descent with the wings level, before impact. The only uncertain factor is the status of the right alternator on impact. Engineers at the CTAISB Engineering Laboratory were not able to determine if the alternator failed before impact, but the fact that the R ALT OUT warning light was not illuminated at impact indicated that the alternator probably did not fail before impact. If it did fail before impact, this may have distracted the pilots' attention, but would not have affected any of the aircraft systems, and is unlikely to have contributed to the occurrence. In the absence of evidence indicating that mechanical problems or crew incapacitation may have caused the accident, it is necessary to consider the effects of the environmental conditions and the evidence that a passenger suffered a heart attack possibly prior to impact.

2.2.1 Flight Conditions

The following scenario is consistent with the conditions and physical circumstances revealed in the investigation and is likely descriptive of what occurred, although it is unsupported by real evidence.

The weather conditions over the flat, featureless, snow-covered terrain would have produced whiteout conditions in which, as a result of light reflected between the snow surface, the falling snow and the low ceiling, no horizon would have been visible to the pilot. In these conditions, depth perception and distance judgement would have been severely reduced.

The flight crew may have felt that they had just enough visibility to attempt continued visual flight, but, in fact, they did not have enough to ensure terrain clearance without reference to flight instruments. It could not be determined why the captain, who was an experienced instrument pilot, would not have utilized his flight instruments.

As the crew completed the instrument approach and started the transition to visual flight, their attention would have been directed outside the cockpit, anticipating and looking for visual contact, in this case perhaps looking for signs of the first logical visual contact along their route. Herron Island, four nautical miles ahead, was the most likely visual contact. Herron Island would have been difficult to see under the existing weather conditions because of the featureless surface and the thin shoreline.

While establishing visual reference, the crew may have spent an extended time looking outside without reference to the instruments. The nose of the aircraft may have then been inadvertently lowered, causing a gradual descent. The crew's visibility could have possibly been further hindered by ice accretion on the windshield.

Alternatively, the pilot may have seen the thin black shoreline of Herron Island in the obscured visibility and thought it was the horizon further away, causing him to lower the aircraft's nose and inadvertently set up a gradual descent to the ice surface. The results of the flight tests mentioned in paragraph 1.16.2 were consistent with this possibility.

2.2.2 Passenger's Medical Condition

The evidence that one of the passengers suffered a heart attack before or possibly at impact introduces the possibility that the pilot was distracted by this situation. However, if the heart attack occurred before or during the time the aircraft was flying the instrument approach at Charlo, it is probable that the pilot would have landed at Charlo. Therefore, if the heart attack did occur before impact, it probably happened during the two-minute period between the aircraft overflying Charlo Airport and the time of impact. However, the likelihood of this occurring during that time is not supported by the fact that the crew made an apparently normal transmission to Bonaventure just prior to impact.

2.2.3 Flight Status Prior to Impact

The evidence leads to the conclusion that, prior to the impact, the aircraft was functioning normally. In addition to other evidence, this conclusion is strongly supported by the fact that the co-pilot made a routine attempt to establish initial radio contact with Bonaventure eight seconds before the crash; there was no indication of any emergency or distress in the co-pilot's voice during this call.

2.3 Search and Rescue Alerting

The delay in alerting Search and Rescue was a result of incomplete communications between Moncton ACC, Montreal ACC, Gaspé FSS, Charlo FSS, and GLUC. The delay would have been avoided if all air traffic control (ATC) units had ensured that they understood the flight crew's intentions.

2.4 ELT Installation

The lead-in wire between the ELT and its antenna was a weak link in that system that prevented the ELT from functioning properly when the wire broke on impact.

2.5 Incorrect Seat Installation

As this accident was not survivable, the incorrect installation of two of the seats was not a factor; in an accident where survivability is marginal, however, the incorrect seat installation could be critical, as the slipper clamps would not be in the correct position to support the seat on impact.

3.0 CONCLUSIONS

3.1 Cause-Related Findings

1. Visual conditions at the time of the accident were conducive to the phenomenon known as whiteout.

2. The aircraft gradually descended in controlled flight until it struck the ice surface.

3.2 Other Findings

1. At take-off, the aircraft's weight was about 400 pounds over the maximum allowable gross and the centre of gravity was within the prescribed limits.

2. The right-hand alternator was in an advanced state of deterioration, but there was no evidence that this contributed to the accident.

3. One of the passengers suffered a heart attack; it is not known whether it related to the accident in any way.

4. The co-pilot made a routine attempt to establish initial radio contact with Bonaventure eight seconds before the crash.

5. Two passenger seats were installed in the aircraft in reverse order to that required by company directions, but this did not affect the survivability of the accident.

6. During the crash sequence, the lead-in wire between the ELT antenna and the ELT transmitter broke, preventing the ELT from transmitting a normal signal.

7. There was a delay of 1 hour 47 minutes in alerting Search and Rescue because ATC misunderstood the pilot's intentions.

8. The flight crew was certified and qualified for the flight in accordance with existing regulations and approved procedures.

9. The aircraft was certified, equipped, and maintained in accordance with existing regulations and approved procedures.

10. There was no evidence of any aircraft malfunction prior to or during the flight.

4.0 SAFETY ACTION

4.1 Action Taken

4.1.1 Procedures to Cancel IFR

The use of incorrect terminology by pilots when changing from an IFR to a VFR flight plan while en route could result in the continuation of a flight with no flight plan at all, and thus with no Search and Rescue (SAR) alerting service. Therefore, on 01 September 1988, the Canadian Aviation Safety Board (CASB) recommended that:

> The Department of Transport amend the procedures for cancelling IFR flight plans to ensure flight following services are continued until the aircraft has arrived at its destination.
>
> CASB 88-04

Subsequently, Transport Canada amended the Aeronautical Information (AIP) to clarify the procedures for changing from IFR to VFR. Transport Canada has also taken action to more fully describe the alerting services provided and to caution pilots regarding the limitations of that service. In addition, FSS specialists have been directed to notify the appropriate Rescue Coordination Centre and to take other action as prescribed by local procedures in the event that information is received concerning any aircraft that is overdue at its destination, regardless of whether or not a flight plan or flight notification was filed with ATS.

4.1.2 Passenger Seat Configuration

The investigation of this accident revealed that it was possible to install passenger seats incorrectly, thereby reducing their structural strength. While this affected neither the cause nor the survivability of the accident, an Aviation Safety Advisory was issued to the Department of Transport suggesting that Cessna 402 operators and aircraft maintenance engineers be alerted to this deficiency. In response, Transport Canada, through its General Aviation Inspection Aids publication, has cautioned aircraft maintenance engineers against the possibility of incorrect positioning of the passenger seats in the Cessna 402 aircraft.

4.2 Safety Concern

4.2.1 Emergency Locator Transmitter (ELT) Failures

According to figures derived from Department of National Defence Search and Rescue statistics, roughly 60 per cent of ELTs involved in crashes in Canada fail to function properly. Activation failures have been attributed in part to time-expired batteries or other battery failure, degradation due to corrosion, malfunction of the equipment's G-switch, and mechanical stress failure. The CTAISB is concerned that equipment intended for emergency use has such a high rate of failure.

To improve the situation, the United States Radio Technical Commission for Aeronautics (RTCA), with international representation from governments and industry, reviewed the technical and performance standards to which existing ELTs were manufactured. The result of this review was a document (RTCA/DO-183) which was approved by the Federal Aviation Administration (FAA) for voluntary use under a new Technical Standard Order for ELTs, TSO-C91a (dated April 1985). This improved manufacturing standard for ELTs is intended to increase reliability following a crash.

In Canada, ELTs manufactured to the new TSO-C91a standards were certified for use in September 1989; however, fitment of the more reliable ELT equipment will not be mandatory pending a thorough evaluation by Transport Canada. Regulations requiring the new equipment fitment will not likely go into effect for at least two years. In the interim, there is no apparent solution to this safety deficiency of unacceptably high ELT failure rates.

The CTAISB is aware that Transport Canada has an active publicity program to inform aircraft owners and operators of the proper care and maintenance of their ELT equipment. The CTAISB fully supports this approach as statistics show that many failures are the result of poor maintenance, particularly with respect to the use of unserviceable batteries and the detection and control of corrosion of the ELT equipment. This publicity campaign should ameliorate but will not solve the basic reliability problems of the existing ELTs.

In an attempt to assist Transport Canada in expediting improved reliability of ELTs, the CTAISB will continue to monitor the performance of ELTs involved in aviation occurrences and will report any findings of related laboratory analyses to Transport Canada's ELT Working Group.

This report and the safety action therein had been adopted by the Chairman, J. W. Stants, and Board Members:

G. E. Bennett
Z. M. Brunet
W. R. DuPont
H. M. MacNeil

LIST OF LABORATORY REPORTS

The following laboratory reports were completed:

LP 26/88 - Wreckage Analysis;
LP 27/88 - Examination of the Engines and Propellers;
LP 31/88 - Fluid Sample Analysis;
LP 86/88 - Vacuum Pump Drive;
FI 35/88 - Electrical Systems Investigation.

These reports are available upon request from the Canadian Transportation Accident Investigation and Safety Board.

APPENDIX B

GLOSSARY

ACC	Area Control Centre
asl	above sea level
AST	Atlantic standard time
ATC	air traffic control
CASB	Canadian Aviation Safety Board
CTAISB	Canadian Transportation Accident Investigation and Safety Board
CVR	cockpit voice recorder
ELT	emergency locator transmitter
FAA	Federal Aviation Administration
FDR	flight data recorder
FSS	flight service station
hr	hour(s)
IFR	instrument flight rules
ILS	instrument landing system
IMC	instrument meteorological conditions
in. Hg	inches of mercury
lat	latitude
lb	pound(s)
long	longitude
MHz	megahertz
N	north
NDB	non-directional beacon
RCO	remote communications outlet
RTCA	Radio Technical Commission for Aeronautics
SARSAT	Search and Rescue satellite
UTC	Coordinated Universal Time
VFR	visual flight rules
VMC	visual meteorological conditions
W	west
°	degree(s)
'	minute(s)
"	